What is a Part Per Million?

Grades

6-8

Subjects

Science – (chemistry)

Duration

45 minutes

Materials

- Small paper cups, styrofoam egg cartons, or beakers (7 containers per group)
  Make sure the inside of the containers are white, or in the case of clear containers, place them over white sheets of paper.
- Eye droppers
- Food coloring
- Make an overhead of the "*Parts Per Million Comparison Sheet*"
- Consumer Confidence Report from your local Public Water System overhead (one is included if you can not obtain your own)
- Lab sheet copies

Objective

Students will be able to witness the difficult to grasp concept of a part per million.

Students will understand that very small amounts of pollution (l part per million or less) can cause adverse health effects in humans.

Students will appreciate the role chemistry plays in protecting human health.

Set

Bring in a copy of your local public water system's Consumer Confidence Report (mailed out annually and available from your local drinking water supplier) or use the example provided with this activity. Turn the report into an overhead and go through the results with your students. The reports list the chemicals present in your drinking water. These results are generally reported in parts per million or the equivalent milligrams per liter (mg/L). Ask your students to try and visualize a part per million. It is difficult. Show them the "*Parts Per Million Comparison Sheet*" overhead. Go thorough some examples. Now inform the students that they will be going through a lab that will produce 1 part per million of "pollutant" in tap water.

Instructional Input

Place the students in groups of 4, hand out the lab sheet, make the appropriate materials available, and go over the procedure with the class. Allow them to work on the lab. Check their math as you observe their progress.

Allow them time to work on the questions before ending the lab. After the lab is over, go over the answers to the lab questions and the follow up questions at the end. Discuss the feasibility of the designed experiments.

Evaluation

Grade the lab sheets individually or as a class as you prefer. A lab key is provided.

Closure

Make sure to discuss the last paragraph on the lab sheet. Many times students question the relevancy of material taught in school. "How does this relate to me?" or "How can I use this in real life?" The ability to grasp the concept of small concentrations is important to understanding the role of environmental contaminants in human health. This lab also shows the importance of chemistry in the protection of human health.

A Part Per Million Lab Sheet

Names ___________________________

Obtain the following materials:

- 7 empty containers
- eye dropper
- tap water
- food coloring

Step 1

Place 6 drops of food coloring into one of your empty containers.
Pour some tap water into another of your empty containers.
The food coloring is a 10% solution of dye and water.
How many parts of water are there for every part of dye?

______________ parts of water for every part of food coloring

Step 2

Rinse the eye dropper. Using the eye dropper, place 9 drops of tap water into an empty container, then place one drop of food coloring into this same container. Stir your new solution. Observe the color difference between the %10 food coloring and the solution you just created. You have changed the amount (concentration) of the food coloring. There is 10 times less food coloring per water than there was in the original food coloring solution.

Now there are ______________ parts of water for every part of food coloring in your new solution.

Step 3

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____ times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 4

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 5

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 6

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____ times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Answer the questions below in complete sentences.

1. In which step did your solution appear to be clear?

2. Was there still food coloring in the solutions that appeared to be clear? How do you know?

3. Describe an experiment you could use to prove the presence or absence of food coloring in the clear solutions.

The US Environmental Protection Agency has placed a limit of **0.01 parts per million** (or 10 parts per billion) of arsenic in drinking water. That is 1% of the concentration (or 100 times less) of food coloring in your solution in step six! So you see, very small concentrations of pollutants, so small you can't detect them by sight, can cause harm to human health. This is one reason chemical laboratory work is important. Chemistry is used protect human health.

A Part Per Million Lab Sheet

Names _______KEY_________

Obtain the following materials:

- 7 empty containers
- eye dropper
- tap water
- food coloring

Step 1

Place 6 drops of food coloring into one of your empty containers.
Pour some tap water into another of your empty containers.
The food coloring you added to the water is a 10% solution of dye and water.
How many parts of water are there for every part of dye?

_____**10**_________ parts of water for every part of food coloring

Step 2

Using the eye dropper, place 9 drops of tap water into an empty container, then place one drop of food coloring into this same container. Stir your new solution. Observe the color difference between the %10 food coloring and the solution you just created. You have changed the amount (concentration) of the food coloring. There is 10 times less food coloring per water than there was in the original food coloring solution.

Now there are ___**100**___________ parts of water for every part of food coloring in your new solution.

Step 3

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is _**100** times less food coloring per water in the new solution than there was in the original food coloring solution. There are now ___**1000**____ parts of water for every part of food coloring in your new solution.

Step 4

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **1,000 times** less food coloring in the new solution than there was in the original food coloring solution. There are now __**10,000**__ parts of water for every part of food coloring in your new solution.

Step 5

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is**10,000 times** less food coloring in the new solution than there was in the original food coloring

solution. There are now **_100,000** parts of water for every part of food coloring in your new solution.

Step 6

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **100,000 times** less food coloring in the new solution than there was in the original food coloring

solution. There are now **_1,000,000** parts of water for every part of food coloring in your new solution.

Answer the questions below in complete sentences.

1. In which step did your solution appear to be clear?

This would certainly occur in step six, possibly earlier depending on observational skills.

2. Was there still food coloring in the solutions that appeared to be clear? How do you know?

There was still food coloring even though it was not visible. The concentration was very low, but it was still there. The food coloring has to be there because no chemical or physical process removed it.

3. Describe an experiment you could use to prove the presence or absence of food coloring in the clear solutions.

The containers could be left out under a heat lamp, causing the water to evaporate. This would leave the food coloring dye behind.

The US Environmental Protection Agency has placed a limit of **0.01 parts per million** of arsenic in drinking water. That is 1% of the concentration (or 100 times less) of food coloring in your solution in step six! So you see, very small concentrations of pollutants, so small you can't detect them by sight, can cause harm to human health. This is one reason chemical laboratory work is important. Chemistry is used protect human health.

Part Per Million Comparison

One part per million is one minute in two years.

One part per million is one second in 12 days of your life.

One part per million is one penny out of $10,000.

One part per million is one is one inch out of a journey of 16 miles.

One part per million is approximately one hole in one in 3,5000 golf tournaments.

One part per million is approximately one bad apple in 2,000 barrels of apples.

One part per million is one drop of dye in 18 gallons of water.

Maximum Contaminant Level Goal (MCLG): the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
Maximum Contaminant Level (MCL): the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
Action Level (AL): the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Regulated	MCL	Our Water	Range of Detection	Sample Date	Violation	Typical Source of Contaminant
Total coliform bacteria	**2**	**1**	**0-1**	**Monthly**	**NO**	**Naturally occurring**
Nitrate as N (ppm)	**10**	**2.65**	**ND–2.65**	**May 1999**	**NO**	**Run off from fertilizer**
Lead (ppb)	**15 AL**	**5.6**	**ND-6.9**	**July 1998**	**NO**	**Corrosive water & home plumbing**
Copper (ppm)	**1.3 AL**	**.25**	**ND-.34**	**July 1998**	**NO**	**Corrosive water & home plumbing**
Alpha/Radiation (pCi/L)	**15**	**5.4**	**ND-5.4**	**Nov 1996**	**NO**	**Erosion of natural deposits**
Fluoride (ppm)	**4**	**.33**	**ND-0.33**	**July 1999**	**NO**	**Naturally occurring**
Barium (ppm)	**2**	**.19**	**ND-0.19**	**July 1999**	**NO**	**Naturally occurring**
Arsenic (ppb)	**10**	**7.0**	**ND-7.0**	**July 1999**	**NO**	**Erosion of natural deposits**
Chromium (ppb)	**100**	**--**	**--**	**--**	**--**	**Discharge from steel and pulp mills**

n/a: not applicable **nd**: not detectable at testing limit **ppm**: parts per million or milligrams per liter **ppb**: parts per billion or micrograms per liter **pCi/1**: picocuries per liter (a Measure of radiation) **mrems/yr:** millirems per year (a measure of radiation absorbed by the body)